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PROSPECT TRENCHING WITH CATERPILLAR-MOUNTED ANGLEDOZERS

BY

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PROSPECTING TRENCHING WITH CATERPILLAR-MOUNTED ANGLEDOZERS[1]

By S. H. Lorain[2]

Mechanized dirt-moving equipment has greatly increased the scope of prospect trenching by lowering the costs and increasing the speed of such work. Where the soil covering was more than 3 or 4 feet deep, operators were quickly discouraged and abandoned surface exploration in favor of shaft sinking, drifting, or diamond drilling; wildcat trenching was seldom undertaken, even where the soil covering was thin. Although power shovels, trench diggers, and draglines are useful under special conditions, caterpillar-mounted angledozers will usually do the same type of work and have a far wider range of adaptability. They are therefore incomparably the most generally useful equipment for the purpose.

Since 1939 the Bureau of Mines has been engaged in a widespread search for minerals useful to the war program; this work required a great deal of pioneer exploration in areas where known outcrops were marginal or subcommercial by pre-war standards. Engineers in charge of field operations were quick to perceive the applicability of mechanized trenching on a fairly large scale, particularly in the Northwestern States, where completely exposed vein-outcrops are rare. Probably no other organization to date has done a comparable amount of angledozer prospect trenching under such a wide range of conditions. The following comments and accompanying cost tables are based on work performed chiefly in Idaho, under a variety of physical and climatic conditions. The most important applications of the angledozer for such work may be described under three heads:

(1) Quick and cheap preliminary exploration of prospects for which the surface exposures are good enough to arouse some interest but which do not warrant diamond drilling or other form of underground exploration. Very frequently a few hours or a few days of work with an angledozer will either eliminate the need for further consideration or justify a more expensive program.
(2) Tracing of veins or other ore structures as a guide to underground exploration.
(3) Trenching of areas in which there is good reason to suspect the existence of ore, but in which there are no outcrops.

The value and scope of this work may be illustrated most clearly by a few specific examples. The job references are to the job numbers given in the cost tables accompanying this paper.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote is used: "Reprinted from Bureau of Mines Information Circular 7294."
[2] District engineer, Western Region, Bureau of Mines, Moscow, Idaho.

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Jobs 1 and 2 were undertaken to investigate a few outcrops of stibnite-bearing quartz veins on a grass- and brush-covered hilltop. Several caved prospect pits and a few short adits, driven many years before, had failed to prove continuity between the outcrops. The results of the first few days of trenching were encouraging. Approximately 3,500 linear feet of trenching, at a direct cost of less than $1,000, resulted in proving one 500-foot ore shoot and several shorter ore shoots along a 2,000-foot zone. Within a few months the owner was shipping high-grade antimony ore. Shipments continued for several years during the period when antimony was considered "strategic."

Job 3 was undertaken to determine the extent and value of a deposit of disseminated antimony ore, which had been exposed by erosion at only one point. The surrounding surface was soil-covered, and the underlying rocks were decomposed for 10 to 20 feet below the surface. A deep sidehill cut was required to reach unoxidized ore. The showing made warranted drilling, which ultimately led to discovery of a large body of high-grade tungsten-antimony ore.

The first part of job 7 consisted of trenching for the projected extension of a lode of cobalt-copper ore, which had been partly explored by underground workings. The first results were discouraging; but a little wildcatting made possible by the equipment led to the discovery of a much larger, parallel lode, on which some diamond drilling was believed to be warranted. The drilling in turn resulted in the discovery of a third lode, which proved of commercial importance.

Other evidences of similar mineralization existed over several square miles; but the surface was entirely ocvered with 3 to 10 feet of soil and a heavy stand of lodgepole pine. Outcrops were practically nonexistent, and the ore was oxidized so deeply that subsurface exploration was necessar to determine metal content. Thorough exploration by drilling would have entailed prohibitive costs. Consequently, large-scale trenching operations were carried on coincidentally with drilling. The purpose of this trenching was, first, to eliminate as much weakly mineralized area as possible and, second, to permit wider spacing of drill holes in the most favorable areas. By trenching to expose the strong gossan ahead of drilling operations, it was possible to locate holes to the best advantage and, at the same time, to obtain visual evidence of the continuity of the ore structure between rather widely spaced drill holes. This resulted in a great saving of high-cost drill footage while permitting a fairly reliable preliminary estimate of ore tonnage.

Jobs 8 and 9 were essentially wildcatting operations to disclose mica-bearing pegmatites in a brush- and tree-covered area of 1 to 2 square miles, where valuable deposits of mica had been discovered at several widel separated points. The erratic habits of pegmatites nullified any attempts at systematic planning. Nevertheless, it was possible to track down a number of hitherto unknown mica pegmatites. Several contained mica ore shoots of commercial importance. The first ore shoot found is producing mica, and exploration is still in progress.

The other jobs listed were similar to one or another of those that have been described. No. 4 exposed a small tonnage of marginal-grade tungsten ore; No. 5 resulted in discovery of a small but high-grade copper ore shoot, which was immediately mined; and No. 6 gave positive information that will be useful in planning drill operations during the coming season.

The experience gained in this work permits several statements to be made regarding the most efficient selection and use of equipment. For work of this nature, no decided preference was formed for any make of machine; the condition of the equipment and the ability of the operator are much more important. Under most conditions, a heavy machine is cheaper than a light one. This is well-illustrated by jobs 1 and 2, where the lighter machine, at a lower rental rate, cost nearly twice as much per cubic yard under identical conditions (table 4); the difference would have been greater in heavy brush or in timber. Jobs 8 and 9 gave nearly the same cost per yard for a heavy and a light machine on the same project; however, the heavy machine was used to clear the way through brush and timber while the lighter machine was used chiefly for clean-up work. In very rough country the heavier machines, with more power, can climb hills where a lower-powered machine cannot follow.

Under most conditions the hydraulic-operated blade is better for prospect trenching than the cable-operated blade. Although many general contractors prefer the cable-operated blade because of mechanical simplicity, the hydraulic blade control provides the power needed for positive digging into the trench bottom.

The ideal conditions for angledozer trenching are on bare or grassy slopes of 20° to 30°, where the overburden is 5 to 10 feet deep. By trenching along the contours, or at a slight down-hill angle across them, the operator can side-cast the soil with minimum waste motion. Steep slopes with less than 4 or 5 feet of soil cover require transportation of dirt to build up a roadway; this results in a tremendous lowering of efficiency. The angledozer is an efficient dirt mover only when the distance moved is very short. This fact also limits the efficiency of the angledozer when trenching on gentle slopes or level ground. If the slope is too gentle to permit side-casting, all dirt must be pushed out one end of the cut; this limits the economic length and depth of the trench. Nevertheless, very good efficiency can be obtained on level ground if the cuts are less than 5 feet deep. Trenches up to 10 feet deep and 100 to 300 feet long have been dug in level country at a reasonable cost.

Trees up to 6 inches diameter, if not too closely spaced, can be efficiently cleared by the heavier (60-hp. or over) machines. Larger timber or very dense growths of light timber should be partly cleared by hand and the stumps blasted. Hardpan, partly decomposed bedrock, and large interlocked boulders or rocks require preliminary blasting if the angledozer is to be used at its greatest efficiency. The relatively high cost per yard of job 6 was due largely to digging partly decomposed bedrock and frozen over-burden without blasting. On the other hand, the cost per yard of job 3 was nearly average, even though more than 25 percent of the material moved was rock in place. Much of this rock was so thoroughly decomposed that it could have been moved by the angledozer without preliminary blasting; however, the efficiency of the equipment would have been greatly reduced and the over-all cost increased.

It is frequently necessary to clean the trench bottom by hand or even to sink shallow hand trenches below the bottom of the dozer trench. However, this work can be closely limited to places where ore structures intersect the main trench. It is also advisable to have an observer always on hand when the angledozer is digging near bedrock. Otherwise, important indications may be exposed and then covered again before they are recorded.

The accompanying cost tables[3] give only the direct cost of prospect trenching because it is believed that this will afford the best basis of comparison. Overhead charges, transportation, and preliminary excavations, such as access trail construction, differ in nearly every case. Furthermore, the equipment is ordinarily used for other purposes, such as hauling supplies beyond the limits of truck transportation, excavating diamond-drill stations, snow removal, etc. On pioneer operations a tractor-dozer for general utility uses has become almost indispensable.

TABLE 1. - Equipment and rental

Job No.	Make	Model	Approx. drawbar hp. rating	Type blade control	Rental basis	Rental rate[1] per Hr.
1	International	TD-40	33-45	Hydraulic	Fully operated	$4.50
2	Caterpillar	D-2	25	do	do	$2.25
3	International	TD-40	33-45	do	do	$4.50
4	Caterpillar	D-7	80-	Cable	Machine only	$5.00
	Allis Chalmers	K.O	54	Hydraulic	do	$6.00
5	Allis Chalmers	S.O	87	Hydraulic	Fully operated	$5.00
6	Cletrac[2]	(1935) 55	55	do	Machine only	$4.00
7	Caterpillar	D-6	55	do	do	$2.93[3]
8	Allis Chalmers[4]	HD-7	60	do	Fully operated	$6.50
9	Caterpillar	40	40	Cable	Machine only	$4.43

[1] Rental includes repair maintenance.
In most cases rental is per hour of actual operation.
[2] Gasoline powered.
[3] At flat rate per month.
[4] Equipped with winch.

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[3] The writer wishes to acknowledge the assistance given by staff engineers of the Idaho District Office, Bureau of Mines, in collecting and compiling the data given in the tables accompanying this paper.

TABLE 2. - Job description

Job No.	Linear feet trenched	Cu. yards moved	Classification of material-cu.yd.			Vegetation	Hand clearing, sq. feet.	Average cross section, feet, depth x width
			Alluvium	Loose rocks and soil	Rock in place			
1	1,800	3,600	3,600			Chiefly grass & sparse brush	0	4.5 x 12
2	1,730	3,940	3,940			do	0	6 x 10
3	600	9,500	6,900		2,600[1]	Medium timber	18,000	21 x 45[3]
4	8,300	8,300	7,800	500		Grass	0	2.25 x 12
5	2,045	6,420	5,020	1,400[2]		Heavy brush & scattered trees	0	6.5 x 13.0
6	3,305	6,600	4,100	2,500		Chiefly grass & small trees	0	9 x 12[3]
7	9,552	50,800	37,900	10,400	2,500	Dense lodgepole pine	0	11.0 x 25[3]
8	11,390	14,800		9,300	5,500	Dense brush and scattered trees	0	3.5 x 10
9	7,200	9,300		5,900	3,400	do	0	3.5 x 10
Totals	45,922	113,260	69,260	30,000	14,000			

[1] 350 cu.yd. required rock drills; remainder drilled with specially designed hand augers.

[2] Numerous granite boulders weighing 1 ton or more.

[3] Side-hill cut. Depth given for up-hill slope.

TABLE 3. - Operating cost in units of equipment hours, labor and supplies

Job No.	Angledozer hours			Lin. feet per hour	Cu. yd. per hour	Fuel and Oil										Man-hours	
						Gal. Diesel oil			Gal. gas.			Gal. lube oil					
	Per lin. ft.	Per cu. yd.	Total			Per lin.ft.	Per cu.yd.	Total	Per lin.ft.	Per cu.yd.	Total	Per lin.ft.	Per cu.yd.	Total	Per lin. ft.	Per cu. yd.	Total
1	0.027	0.013	48	37.5	75.0										0.053	0.027	96
2	.081	.035	140	12.3	28.0										.106	.046	183
3	.297	.016	178	3.4	63.3										2.738	.147	1,657
4	.017	.017	142	58.7	58.7										.017	.017	142
5	.100	.031	200	10.0	32.1										.100	.031	200
6	.100	.050	330	10.0	20.0				0.22	0.11	720	0.02	0.01	66	.320	.160	1,056
7	.113	.021	1,081	8.9	47.4	0.259	0.048	2,422				.03	.005	281	.182	.034	1,753
8	.032	.025	369	30.9	40.0										.077	.059	881
9	.031	.025	234	32.0	39.7	.091	.070	660	.007	.006	55	.019	.015	140	.091	.073	678
	.059	.024	2,722	17.0	42.4										.144	.058	6,646

TABLE 4. - Operating cost - dollars

		Equipment cost	Rental - Fuel - Oil			Labor cost2/			Total direct cost3/		
Job No.	Rental	Fuel1/ and lubricants	Per lin.ft.	Per cu.yd.	Total	lin.ft.	cu.yd.	Total	lin.ft.	cu.yd.	Total
1	216.00		0.12	0.06	216.00	0.02	0.01	28.20	0.14	0.07	244.20
2	315.00		.18	.08	315.00	.12	.05	213.20	.30	.13	528.20
3	801.00		1.34	.08	801.00	1.93	.12	1,160.30	3.27	.21	1,961.30
4	800.00	52.90	.10	.10	852.90	.03	.03	218.00	.13	.13	1,070.90
5	1,000.00		.49	.16	1,000.00				.49	.16	1,000.00
6	1,015.03	153.99	.35	.18	1,169.02	.28	.14	923.49	.63	.31	2,092.51
7	3,853.31	307.28	.43	.08	4,160.59	.26	.05	2,497.01	.70	.13	6,657.60
8	2,392.00		.21	.16	2,392.00	.04	.03	449.00	.25	.19	2,841.00
9	1,041.05	125.01	.16	.12	1,166.06	.07	.06	498.97	.23	.18	1,665.03
	11,433.39	639.18	.26	.11	12,072.57	.13	.05	5,988.17	.39	.16	18,060.74

1/ Included in rental unless otherwise stated.
2/ Operators' time included under rental when equipment rented on fully operated basis.
3/ Nominal explosive costs not included.

The foregoing data show that prospect trenching by angledozer may be done at from one-half to one-tenth the cost of hand trenching per linear foot and at imcomparably greater speed. The greater width of the trench bottom permits much better observation of geologic structure and more accurate sampling of any veins or lodes exposed. Furthermore, the trenches will remain open to inspection for much longer periods. These factors have greatly increased the usefulness of trenching as an aid to preliminary exploration in soil-covered areas.

Most of the outcrop discoveries in mining districts of Western States were made between 1860 and 1900. A considerable, but rapidly diminishing, number were made between 1900 and 1920, but very few new discoveries have since been made. It is concluded that most exposed vein outcrops in this region have been discovered, but that additional outcrop discoveries will result from the more general use of mechanical trenching equipment.